Swine Logistics Assessment post-farm to market

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ABSTRACT

Brazil is one of the most important producers, exporters and consumers of swine in the world. Among all states, Santa Catarina stands out in the national scenario. The main producing area in this state is about 500 km away from the nearest seaport, so that the logistic involves two steps: (a) live weight transportation to the slaughterhouse, and (b) frozen carcass through refrigerated transportation to market. Those features influence the environmental performance of the final product. We applied the Life Cycle Assessment methodology to analyze five different scenarios performing carbon footprint (CF) and energy demand (ED), varying slaughterhouse location and thus distances of cooling and live transportation. In general, results showed that lower live weight distances would represent lower impacts on CF and ED, although it is possible to reach an optimum mortality rate that would invert scenarios rankings.

Keywords: LCA; Logistics; Post-farm, Swine, Brazil

1. Introduction

Brazilian swine production is an important activity, with a herd of 35 million heads, representing the fourth largest producer (3 millions ton/year), fourth largest exporter (600 thousand ton/year) and the sixth largest consumer (11–13 kg/inhabitant/year) in the World (Kunz et al. 2009; USDA 2013). In this context, Santa Catarina state (southern Brazil) is the largest producer in the country, with 19.3% of the national herd (IBGE 2012).

The swine production chain in Santa Catarina can be described in 5 major steps, commonly known as piglet production, weaning to finishing, slaughtering (meat processing), market and consumption. Several Life Cycle Assessment (LCA) studies concluded that its main environmental hotspot lies in the livestock processes (Basset-Mens; van der Werf 2005; Dalgaard, 2007; Elferink et al. 2008; Eriksson et al. 2005; Kingston et al. 2009; Kool et al. 2009; Nguyen et al. 2011; Wiedemann et al. 2010) due feed production and animals emissions. With reflection, this step has been widely studied in order to reduce impacts.

Nonetheless, there are other production processes that can be assessed in order to improve pork's ecoprofile, or indicate preferable paths inside its production chain. For instance, after the weaning-to-finishing process, swine have two logistic steps before reaching the final consumer: (a) liveweight transportation to the slaughterhouse, and (b) frozen carcass transport through refrigerated transportation to market (internal or external).

Food transport refrigeration is a critical link in the food chain not only in terms of maintaining the temperature integrity of the transported products but also its impact on energy consumption and CO_2 emissions (Tassou et al. 2009). In these processes mechanical refrigeration technologies are invariably employed and they contribute significantly to the environmental impacts of the food sector (Tassou et al. 2010).

The impact of this technology varies depending on the distances and types of transportation involved. Those features also influence the environmental performance of the food final product. Transportation type (a) can have lower environmental impacts than type (b), since refrigerated transportation requires more inputs (e.g. fuel and refrigerant gases). However, long distances for live weight transportation are related with animal's welfare reduction, what can bring high mortality for the swine (up to 1%) (Alverós et al. 2008; Gonsalvez et al. 2006; Vecerek et al. 2006).

When it occurs, swine loss (during handling and transport) is usually preceded by a period of poor welfare (European Commission, 2002). Potential factors influencing this issue have been compiled (Adams, 1994; European Commission, 2002; Broom, 2005; Schwartzkopf-Genswein et al., 2012) and strategies have been developed to provide better welfare (European Commission, 2002; Broom, 2005; Silveira, 2013).

Brazilian laws are out of date (Silva et al. 2009) and are more focused on breeding and slaughtering processes (Brasil, 1952; 2000; 2008; 2011). Although, EMBRAPA and Brazilian Association of Swine Breeders have created a Manual of Good Agricultural and Livestock Practices in Swine Production (2011).

Since meat products have its main environmental hotspot in the livestock processes, any loss on finished swine represents higher environmental impacts.

Therefore, the aim of this study was to find the best combination on swine logistics post finishing to market. We applied LCA methodology to compare possible scenarios for Santa Catarina state, an important swine producer in Brazil. Seeking for lower Carbon Footprints (CF) and Energy Demand (ED), we evaluated five different scenarios to deliver frozen swine to São Francisco do Sul's City Seaport, 500 km away from the producer city, Concórdia.

2. Methods

Lived swine on conventional transportation (normal truck) to the slaughterhouse, and then refrigerated transportation to the harbor (for export) or storage (for national consumption), was varied in five scenarios, as shown in Table 1.

The Functional Unit (FU) was 10 tons of refrigerated swine delivered at the seaport. Therefore, the reference flow was 10 tons of frozen carcass in refrigerated transportation and 13.5 tons in live weight transportation.

Scenario 01(SC 01) was designed to represent a swine that is entirely transported frozen until the seaport. In this case, the slaughterhouse is hypothetically located beside the swine producers, therefore there is need for only a 50 km range of live weight transportation, from producers to the meat processing industry. This scenario featured a transportation with minor live swine losses due the lower distance attributed to the live weight transport, although represents a higher diesel consumption for refrigerated transport and other inputs and outputs such as refrigerant gases, due to cooling.

Scenario 05 (SC 05) is the opposite, with meat processing near to the seaport, and all the transport by regular trucks until the slaughterhouse. In this case, live transport does imply in meat losses, but on the other hand, fuel consumption is lower.

Scenario 03 (SC 03) is equalized with the same distances between producers, slaughterhouse and the seaport. Thus was modeled in 250 km for both kinds of trucks. Scenarios 02 (SC 02) and 04 (SC 04) were designed to have the slaughterhouse near the producers or near the seaport respectively, in a range of 100 km, varying transportations types.

Other characteristic of live weight transportation is that it carries more mass due to inedible offal. Although some parts are allocated after slaughtering, it means 35% more ton.kilometers^{-1} compared to frozen transportation. This difference is equalized by reference flow.

Table 1. Distances for modeled scenarios.

Scenario	Live weight transportation	Frozen transportation
SC 01	50 km	450 km
SC 02	100 km	400 km
SC 03	250 km	250 km
SC 04	400 km	100 km
SC 05	450 km	50 km

To create the inventory, primary data were collected from an Agroindustry for trucks, both refrigerated and regular, diesel consumption, truck type and capacities, live and deadweights, transport losses and city locations. The swine mortality accounting was from Cherubini et al. (unpublished data). For welfare conditions and swine losses rates, see Alvaróz et al., (2008); and table 2 based on not fasted pigs (Alvaróz et al., 2008) respectively. Other data was collected from literature and Ecoinvent Database® (for refrigerant gases). Data from cooling machinery production were not included.

Table 2. Life Cycle Inventory.

Scenario	Live cargo transportation	Amount	Frozen cargo transportation	Amount
All	Transport, lorry 16-32 ton/Euro3/EUR R	Table 1	Adapted from Transport, lorry 16-32 ton/Euro3/EUR R (135% higher diesel consumption**; Refrigerant gas[1])	Table 1
SC 01	Swine Losses*	33.7 kg	-	-
SC 02	Swine Losses*	43.2 kg	-	-
SC 03	Swine Losses*	54.0 kg	-	-
SC 04	Swine Losses*	70.2 kg	-	-
SC 05	Swine Losses*	80.8 kg	-	-

* Alvaróz et al (2008)
**Tassou et al. (2009)
[1] Personal communication, from south Brazilian agroindustry.

The Life Cycle Impact Assessment was performed with the software SimaPro® 8.0 using the CML-IA method for CF and the Cumulative Energy Demand method for ED.

3. Results and Discussion

Results have shown better environmental performance to the SC 01 with the shortest distance between producer and slaughterhouse (50 km), despite of the long distance covered by refrigerated transport (450 km). This scenario had 1.07 ton CO_2 eq. and 18,268.05 MJ eq. (Table 3), values 27% and 15% lower than the worst scenario (SC 05), with the slaughterhouse near the seaport (Figure 1). These emissions represent approximately 3% of the total cradle-to-gate swine production chain, based on Dalgaard (2007).

Table 3. Life Cycle Impact Assessment.

Impact category	Unit	SC 01	SC 02	SC 03	SC 04	SC 05
Global warming (GWP100)	ton. CO_2 eq.	1.07	1.13	1.25	1.39	1.46
Total cumulative energy demand	MJ eq.	18,268.05	18,745.15	19,883.33	21,111.71	21,611.36

The other scenarios are between SC 01 and SC 05 for both impact categories, with SC 02 representing lower impact than SC 03 that represents lower impacts than SC 04.

As it can be seen in Figure 1, SC 02 is 4% higher on CF and 2% higher on ED than SC 01, while SC 03 is 9% and 5% higher than SC 02 and SC 04 also presents this pattern with values 10% and 6% higher than the last scenario.

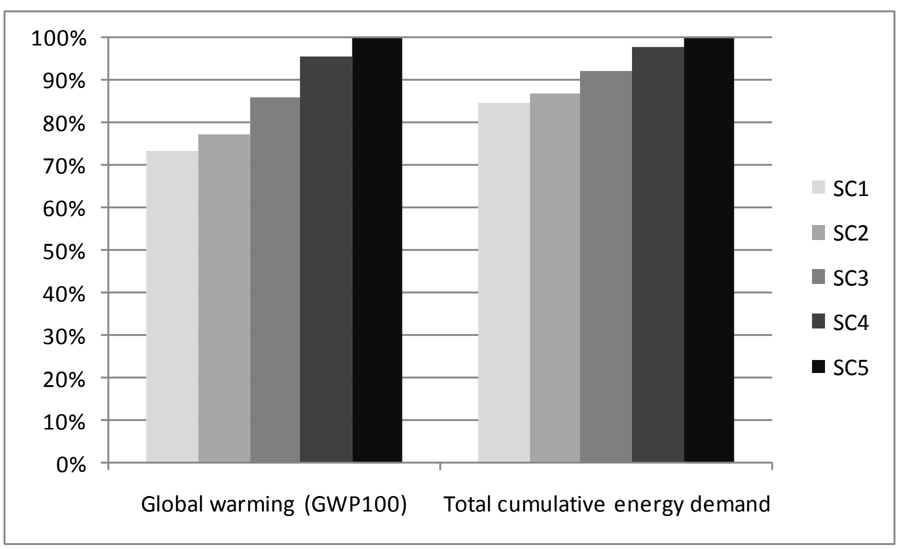

Figure 1. Environment impact comparison.

The difference in performance between lower and higher scenarios (SC 01 and SC 05) occurs due to swine losses during the long live weight transportation and also due to higher mass transported per km, even allocating slaughterer byproducts (i.e. offal). Swine losses means that impacts from feed production and animal rearing are attributed to live weight transport.

Analyzing extreme scenarios (SC 01 and SC 05) without live swine losses, we found that the CF is still higher for live weight transport, i.e., SC 01 remains better. On the other hand, for ED, SC 05 becomes preferable to SC 01. On top of that, it is possible to indicate an optimum rate of mortality where live weight transport could be the best choice.

5. Conclusion

This paper performed a LCA of swine logistics scenarios post-farm to market, varying conventional transportation (live weight) and frozen carcass transportation (cooling trucks) distances, with different inputs and outputs. Scenarios were based on the Santa Catarina state reality, from Concórdia until São Francisco do Sul, with support from an Agroindustry for providing primary data.

Locating the slaughterhouse as near as possible to producers would reduce the impacts around 27% and 15% for CF and ED, respectively, if compared to locate the meat processes near final destination (i.e. seaport for exportation).

It is clear that for CF, the reduction of live weight transportation yields better environmental performance. This statement is also true for ED results (for scenarios assessed). Although for ED, decreasing swine losses in live weight transport would allow one to reach lower energy consumption than frozen transport. Hence, it is possible to reduce mortality rates to invert scenarios' rankings. Nevertheless, the first step to reach a better environmental performance is to reduce swine losses on transportation.

These results lead us to a conclusion that they are in accordance with the recent reports on livestock as well as recent laws, where animal welfare provision is recommended and required. Besides its ethical side and influence on meat quality, animal's welfare can lead to a decrease on potential environmental loads through swine's death reduction.

Other environmental impact categories would be relevant to evaluate the overall environmental performance. For instance, frozen transportation could be a significant source for toxicity and ozone layer depletion impact categories. There is lack of cooling machinery data in this study, but it would not change the results significantly because the machinery lifespan is long and could be used for many FU, such that its impacts would be diluted.

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Proceedings of the 9th International Conference on Life Cycle Assessment in the Agri-Food Sector

LCA Food 2014

8-10 October 2014 - San Francisco

Rita Schenck and Douglas Huizenga, Editors
American Center for Life Cycle Assessment

The full proceedings document can be found here:
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It should be cited as:

Schenck, R., Huizenga, D. (Eds.), 2014. Proceedings of the 9th International Conference on Life Cycle Assessment in the Agri-Food Sector (LCA Food 2014), 8-10 October 2014, San Francisco, USA. ACLCA, Vashon, WA, USA.

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ISBN: 978-0-9882145-7-6